

2 to 1 rhythm occurs the quickening of auricular rate is less prompt than is the slowing when a 2 to 1 rhythm changes to the normal. An explanation for this circumstance may be found in the fact that resumption of normal rhythm after a 2 to 1 rhythm at once relieves the auricle of back pressure and the consequent stimulus to increased rate. Such a sudden relief is followed by prompt re-adjustment of auricular activity, whereas the effect of change from normal to a 2 to 1 rhythm and the consequent gradual overfilling of ventricle and auricle would be met by a slower response.

In this case during the time of complete block the ventricular rhythm was not at all times regular, as has been already mentioned, although the ventricle usually contracted about 20 times to the minute, or about every three seconds; at other times there were irregular pauses, the longest being 5.4 seconds. There were, however, no extrasystoles at any time. It is known from physiological experiment that, owing to poorly developed or retained independent rhythmicity, a portion of the ventricle, as, for example, the severed apex of the ventricle, tends to cease contracting after a time and will resume regular contractions only after an external stimulation. It is, therefore, possible that the continued action of the ventricle sometimes for long periods and despite occasional long pauses in cases of complete block may be due to the stimulus of distention with blood resulting from the continued auricular action.

THE TREATMENT OF ANEURYSM OF THE AORTA BY THE INTRODUCTION OF WIRE AND THE PASSAGE OF A GALVANIC CURRENT.¹

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ANEURYSM of the aorta is essentially a fatal disorder sooner or later, partly on account of the resulting interference with the blood distribution and pressure phenomena, but largely and inherently because of the underlying degenerative state of the vessel wall, so that if correction or repair be effected in one situation, active manifestations are likely to appear in another situation. The affection is almost invariably associated with more or less widespread atheroma of the arterial system, and antecedent syphilis appears to be far and away the commonest cause. The dilatation or diverticu-

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lation of the bloodvessel must, accordingly, be looked upon merely as a local expression of changes widely distributed throughout the vascular system, and accordingly the results of any therapeutic procedure can at best be only palliative, except in the small group of cases in which the lesion arises from purely local influences, such as traumatism or adjacent disease. Nevertheless, it will not be gainsaid that measures of temporary relief are often indicated, either for the amelioration of symptoms or for the prolongation of life. In this connection the fact should not be ignored that under certain conditions life may be continued for many years in the presence of an aneurysm and also that a sacculated aneurysm of the aorta may, and occasionally does, undergo spontaneous cure by the total occlusion of the aneurysmal sac by fibrous laminated adherent clot, and be discovered at autopsy only as an incidental phenomenon. Furthermore, it is impossible to foresee the outcome of the brilliant experimental work that has been done and is being continued in the plastic surgery of the vascular system. Nevertheless, there will remain cases in which symptomatic treatment only will be possible.

In the treatment of aneurysm of peripheral vessels, with abundant anastomotic connections, deligation, with or without excision or resection of the aneurysmal sac, has yielded satisfactory and at times even brilliant results, but this mode of procedure is scarcely applicable to aneurysm of the aorta, and more particularly, its thoracic division, partly on account of anatomical limitations with respect to the establishment of a collateral circulation, and partly by reason of the practical inaccessibility of the disease focus. Various modes of treatment, dietetic, medicinal, physical, have been applied to aneurysms of the latter class, with varying measure of success. Among the most rational and most useful of these may be mentioned rest, restricted diet, ergot, iodides, calcium chloride, adrenaline, introduction of foreign bodies, electricity. Of foreign bodies there have been introduced into the aneurysmal sac substances such as horsehair, catgut, silk, watchspring, needles, and wire of various kind.

Charles H. Moore and Charles Murchison² first employed fine iron wire in this manner, introducing twenty-six yards through a cannula into an aneurysm of the thoracic aorta. The tumor was at first reduced in size, but subsequently it became larger, and the patient died on the fifth day. Postmortem examination disclosed abscess of the left kidney and pericarditis.

The possibility of treating aneurysm by transfixion with needles occurred to Velpeau³ and to Benjamin Phillips;⁴ while Ciniselli⁵

² Medico-Chirurgical Transactions, 1864, xlvii, 129.

³ Memoires de l'Academie des Sciences, December, 1830.

⁴ Medical Gazette, 1831, 499; also pamphlet, A Series of Experiments for the Purpose of Showing that Arteries may be Obliterated without Ligature, Compression, or the Knife, 1832.

⁵ Gazette des Hôpitaux, 1868.

recommended galvanopuncture or electrolysis by means of needles introduced into the aneurysmal sac.

Burresi and Corradi^{*} introduced 42 cm. of No. 30 annealed wire through a cannulated needle into the sac of a large aneurysm of the ascending division of the arch of the aorta, and passed a constant current. Temporary improvement ensued, but death took place three and a quarter months after the operation. This latter procedure variously modified has since been carried out in a moderate number of cases—of which I have been able to tabulate 38—and the results appear to justify its employment under suitable conditions. It is applicable only to sacculated and not to fusiform aneurysms, particularly if lesser measures have failed, and even and perhaps especially when alarming symptoms are present or rupture is threatened. The most that can be hoped for under such circumstances is amelioration of symptoms and prolongation of life, and these ends have been attained in most instances in which the procedure has been employed. In isolated instances the inevitable fatal issue appears to have been hastened, but in the vast majority the intervention has been justified by the results.

The technique of the procedure is extremely simple. Under aseptic conditions a hollow needle of gold, silver, or platinum, insulated except at its tip, is introduced to a considerable distance into the most prominent part of the aneurysmal sac, care being taken to avoid puncture of the remote opposite side of the vessel-wall. Through the needle gold or silver wire is fed in amount sufficient loosely to fill the sac. Ordinarily ten or twelve feet of wire will be sufficient. Should the wire kink before the desired amount is introduced, the needle may be withdrawn and introduced in another situation, or a second needle may be introduced, and wire insinuated through it. Indeed, several needles may be introduced at the same sitting. The end or ends of wire are connected with the positive pole of a galvanic battery and a current gradually increased to 60, 80, or 100 milliampères and as gradually decreased, is passed over a period of from an hour to an hour and a half. The negative pole of the battery is placed upon some indifferent point, as upon the back. A spurt of blood usually follows introduction of the needle, but the hemorrhage is not considerable and it soon ceases. Pulsation may begin to subside during the introduction of the wire, but, as a rule, this effect does not appear until the passage of the current, and at the same time the patient often expresses relief from distressing symptoms, such as pain and dyspnoea. In many instances the improvement is progressive and persists for a varying period of time, and in one case it was maintained for nearly twelve years. The operation is remarkably free from accident or complication, transient hemiplegia having been exceptionally observed. Death

^{*}Lo Sperimentale, April, 1879, p. 445.

may result from hemorrhage or the effects of pressure and exhaustion, or from rupture of a second aneurysm, and at times from an entirely unrelated cause. Only sacculated and not fusiform aneurysms are suitable for the operation. Experience and experiment have shown that gold or silver wire is the best to employ, the latter having the advantage of lesser cost. The positive pole is preferred for connection with the wire on account of the firmer clot produced at this pole.

In addition to the recorded cases, I am able to report two that have recently been under my observation.

CASE I.—A sheetmetal worker, aged sixty-four years, was admitted to the Philadelphia General Hospital March 26, 1909, complaining of dyspnea, pain on both sides of the chest, cough, expectoration, headache. The dyspnea has been present for a year, and had become worse six weeks previously. At this time the pain in the chest appeared, and a cough of long standing became aggravated. The man had worked at his trade until four weeks before admission to the hospital, when he was compelled to give up on account of the difficulty in breathing. Physical examination disclosed the signs of effusion into the left pleural cavity, and on aspiration about three pints of clear serous fluid were evacuated. The apex-beat of the heart, which previously had been one and a half inches to the right of the sternum, receded to the left of the sternum. The normal heart sounds were replaced by murmurs, but little transmitted. The voice was hoarse, and there was a metallic cough. Bulging, with pulsation, was visible on the upper anterior aspect of the left chest, with dullness on percussion and a to-and-fro murmur on auscultation. Tracheal tugging was distinct. The percussion note over the greater part of the left chest was dull, with diminished vocal resonance and fremitus, and friction sounds toward the base. Over both lungs bubbling rales were audible. On laryngoscopic examination the left vocal band was found immobile. The urine was free from albumin and sugar. X-ray examination disclosed an aneurysm of the aorta.

As the swelling and the pulsation of the left chest increased and the general symptoms grew worse the proposition was made to the patient that wire be introduced into the sac and a galvanic current be passed, and in this he acquiesced. Accordingly, on April 24, 1909, after injecting $\frac{1}{4}$ grain of morphine hypodermically, and inducing local anesthesia with cocaine, Dr. Ralph S. Lavenson introduced at the most prominent point an insulated hollow gold needle in the second interspace just to the left of the sternum. A small amount of dark, thick blood oozed from the needle. About twelve feet of gold wire was introduced into the sac, blood meanwhile flowing more freely. The end of the wire was connected with the positive pole of a galvanic battery, while a large wet pad connected with the

negative pole was applied to the back. The current was started at 5 milliampères and thus continued for three minutes, being increased 5 milliampères every succeeding three minutes until a total of 60 milliampères was reached. It was maintained at this level for ten minutes, and then gradually reduced 10 milliampères every three minutes. Fifty-eight minutes were consumed in the passage. During its progress pulsation diminished. The patient withstood the operation well and made no complaint of pain. Subsequently there was temporary return of the pain on both sides of the chest. For a time also a tender swelling made its appearance at the site of puncture, but this soon subsided. The patient, however, failed to gather strength, and troublesome cough persisted, and without the development of other symptoms death took place from exhaustion on May 22, 1909, four weeks after the operation.

There was some delay in securing an autopsy, and this was not held until five days after death. The body has been embalmed and was in a good state of preservation. The right lung was bound by moderate adhesions, which were readily detached. The left lung was held by more numerous and firmer adhesions, and it was greatly compressed. The anterior mediastinum was occupied by the heart and a large, firm mass. The heart was in a somewhat transverse position, the right auricle being situated to the right and the right ventricle to the left, while the left auricle and ventricle were altogether posterior. The pericardial cavity was obliterated by adhesions. The ascending and transverse portions of the arch of the aorta were the seat of an immense aneurysm as large as a child's head, and almost entirely filled with clot which in places had undergone fibrous transformation, and in the midst of which was a coil of gold wire. The descending portion of the arch and the thoracic aorta were the seat of marked atheroma, with calcareous deposits. The liver was large, hard, and cirrhotic. The kidneys were large and cyanotic, with parenchymatous and interstitial changes. The spleen was soft and voluminous. The lungs were firm and on section frothy.

CASE II.—V. M., an Italian laborer, aged fifty-nine years, was admitted to the Philadelphia General Hospital, September 10, 1908, complaining of precordial pain, cough, expectoration, dyspnoea, and weakness. He had been a saloonkeeper for thirty-two years and had indulged in alcohol to excess. He had suffered from several of the diseases of childhood, from smallpox at six, and he had had an attack of gonorrhoea at twenty, and a chancre at thirty. For eight months he had been complaining of pain in the precordium, progressive in severity, radiating in the course of the great vessels and extending down the left arm, together with cough and expectoration. The pulse was small, slow, and thready, the right smaller and slower than the left. Pulsation was visible in the vessels of the neck. The chest

was barrel-shaped and presented a pulsating swelling to the left of the sternum between the second and fourth intercostal spaces, and yielding dulness on percussion. No thrill was palpable, but a bruit was audible on auscultation. The action of the heart was deliberate, rhythmic, and forcible; the first sound was clear, the second accentuated at the base. The pupils were moderately dilated, but they reacted to light and in accommodation. The urine was free from albumin and sugar. Skiagraphic examination disclosed an aneurysm of the arch of the aorta. On September 28, fourteen feet of gold wire was introduced by Dr. Ralph S. Lavenson into the pulsating mass, and a galvanic current was passed. The current strength was begun at 5 milliampères and was gradually increased to 75 milliampères and as gradually reduced. The patient was somewhat restless during the course of the procedure, and he coughed slightly with each increase in the strength of the current. Relief was afforded by a hypodermic injection of morphine, $\frac{1}{4}$ grain, and the patient slept for a portion of the time. Pulsation soon diminished and became almost imperceptible. Pain, however, persisted, and at a later date pulsation returned. On May 1, 1909, the patient went to visit friends, and he returned on May 5 with a pulsating mass of increased size at the site of the earlier swelling. Death took place suddenly on May 6, seven and one-fourth months after the operation.

On postmortem examination a globular swelling was visible upon the anterior aspect of the left side of the chest between the second and fifth ribs and the median and nipple lines, and the centre of which exhibited a dark-red discoloration. The underlying third rib was fractured. The right pleural cavity was free and the right lung was covered at its apex by a small area of thickened pleura, but it was in other respects normal. The left pleural cavity contained 200 c.c. of slightly cloudy, straw-colored fluid, in which floated flakes of fibrin. The pleural surfaces were moist and glistening. The left lung was pale gray in color and crepitant throughout. On section a considerable amount of frothy fluid escaped. The pericardial cavity contained a large amount of currant-jelly clot under such pressure that it was forcibly extruded when the pericardium was incised. The heart was flabby and covered by a considerable amount of epicardial fat. The myocardium was pale and cloudy. All of the chambers of the heart were dilated, but the walls were not hypertrophied. The valves and orifices presented no abnormality. The aorta was extremely atheromatous, the intima in places being punctured and fissured. The ascending and transverse portions of the arch of the aorta were greatly dilated and from the anterior aspect of the latter bulged a large sacculated aneurysm measuring 8 x 6 cm. The sac was largely filled by organized thrombus and recent blood clot, in the midst of which,

loosely coiled, lay 350 cm. of fine gold wire. The overlying third rib was partially eroded and fractured, and the aneurysm was adherent to the second and fourth ribs. A short distance above the aortic cusps the vessel wall was softened and eroded, and it was at this point that the fatal hemorrhage into the pericardium had taken place. Several other weakened spots in the wall with beginning bulging were visible in other parts of the aorta. The spleen was considerably enlarged. It was friable and it tore in removal. Its structure was pale, the capsule presenting a variegated appearance, with dark and red spots. The kidneys were pale and flabby, the capsule stripping easily and leaving a smooth surface behind. On section they presented a cloudy appearance, the cortex being slightly increased in thickness and pale in color. The right kidney was smaller than the left. The liver was enlarged and measured 20 x 18 x 9 cm. It was pale and flabby and its capsule was smooth. Section presented a dirty yellow appearance; the acini were not visible.

The accompanying table comprises 34 cases that I have been able to collect from the literature, together with 2 cases recently reported by Beardsley, Rhoads, and Saurman at a meeting of the College of Physicians of Philadelphia, February 3, 1910, and the two cases of my own.

In addition Hunner⁷ refers to a case of Dr. John Neff, of Baltimore, in which operation was performed on three occasions by D. D. Stewart, of Philadelphia, and apparently not otherwise reported. The patient was a travelling salesman, with a large thoracic aneurysm; ten feet of wire was introduced February 5, ten feet April 1, and five feet June 5. Death took place from rupture and hemorrhage November 17.

Dr. Robert N. Wilson, Jr., of Philadelphia, informs me that he has treated 3 cases of aneurysm of the ascending portion of the arch of the aorta and 1 case of aneurysm of the descending portion by the introduction of 15 feet of gold wire and the passage, throughout an hour, of a galvanic current gradually increased to 160 milliamperes and then gradually diminished. In three of the patients death appeared imminent, and although they were helped symptomatically, life was prolonged but a few days. One had been wired twice previously without advantage, and the patient was able to return to work after the third operation, and was still living at the date of Dr. Wilson's letter to me.

Of the 38 cases included in the table that I have prepared, 36 occurred in males, 1 in a female, and in 1 the sex was not mentioned. The age of the patient was mentioned in 35: Five were between twenty-five and twenty-nine, 3 between thirty and thirty-four, 6 between

⁷ Loc. cit.

thirty-five and thirty-nine, 7 between forty and forty-four, 4 between forty-five and forty-nine, 4 between fifty and fifty-four, 4 between fifty-five and fifty-nine, 1 was sixty-four, and 1 was seventy-three. The arch of the aorta was the seat of the aneurysm in 18 cases (ascending portion in 9, descending portion in 3, "arch" in 2, transverse portion in 2, ascending and transverse portions in 1, transverse and descending portions in 1), the thoracic aorta in 5, the abdominal aorta in 5, the innominate artery in 3, the subclavian artery in 2, the superior mesenteric artery in 2, the thoracic and abdominal aorta in 1, the splenic artery in 1, and the celiac axis in 1. Gold wire was used in 16 of the cases, silver wire in 15, steel wire in 4, and silver-plated copper wire in 1. The duration of life following the operation was as follows: Five and one-half hours in 1, twenty-four hours in 1, forty hours in 1, forty-two hours in 1, two days in 1, five days in 1, six days in 1, seven days in 1, nine days in 1, eighteen days in 1, twenty days in 2, three weeks in 1, twenty-three days in 1, three and one-half weeks in 1, four weeks in 1, five weeks in 1, forty-seven days in 1, two months in 1, eleven weeks in 1, three and one-fourth months in 1, four months in 1, five months in 1, six months in 2, seven months in 1, seven and one-fourth months in 1, eight months in 2, eight and one-half months in 1, ten months in 1, fourteen months in 1, three and one-half years in 1, five years in 1, eleven years and eight months in 1. One patient was living three years after the operation, but his subsequent history is unknown (Kerr, *loc. cit.*).

CONCLUSIONS. Aneurysm of the aorta is essentially a fatal disorder, although exceptionally spontaneous cure takes place. Accordingly, treatment can, as a rule, be only palliative, relieving symptoms and prolonging life. Deligation is inapplicable from anatomical considerations. Rest, ergot, iodides, gelatin, calcium chloride, adrenalin chloride and introduction of foreign substances, with or without the passage of a galvanic current, have been employed. Horsehair, catgut, needles, watchspring, and wire of various kind have been introduced, with varying result, and a galvanic current has been passed through conducting substances. Wiring with electrolysis has been employed in a moderate number of instances, with satisfactory results in the majority. The procedure has proved simple and safe, but it is applicable only to sacculated and not to fusiform aneurysms.